

Space Weather Technical Forecast

Issued on Sunday, 18 June 2023 at 01:14 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales <https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales>

Space Weather Forecast Headline: Chance of R1/R2 Radio Blackouts throughout. Active electron fluence Expected by end of weekend.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Low over the past 24 hours, with the largest event an C4.4 at 17/1657UTC, originating from AR3338 in the northeast quadrant.

There are currently six sunspot regions on the visible disc. The largest and most magnetically complex is AR3335 (Ehi/Beta-Gamma-Delta), which contains a couple of weak delta spots in its leading portion. The next largest region is AR3333 near centre disc, although appears to be relatively stable at present. Newly numbered AR3339 is close to the southeast limb, although appears to be a simple Hsx configuration. All other spots appear generally stable. A prominence eruption occurred in the northwest near ex-3338 at 17/1630UTC, which produced a CME and is pending analysis. Meanwhile, a large filament in the northwest quadrant has recently lifted off the disc, which has the potential to produce an Earth-directed CME given its location. Currently awaiting imagery analysis. Peripheral CMEs observed in the period have been analysed and modelled and none of these carry Earth-directed components.

Solar Wind / Geomagnetic Activity: The solar wind, as measured by ACE and DSCOVR and L1, was reflective of ongoing connection to coronal hole CH12/-. The solar wind speed saw a very gradual reducing trend from approximately 620km/s down to around 500km/s. The solar wind density was level in single figures ppcc throughout. The IMF was weak throughout. The north-south component has oscillated at weak levels, with Bz ranging between +4 and -3nT. The phi angle was negative (towards the Sun) throughout. The net result of the above solar wind measures was Unsettled to Quiet (Kp1-3) geomagnetic activity.

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV), as observed by GOES16, was at Background levels.

High energy electron flux (greater than 2MeV), as observed by GOES16, rose from generally Moderate to High levels, with a peak of 1620 pfu at 17/1545UTC. The associated 24-hour fluence remained well below the Active threshold (1e8 integrated pfu), with an increasing trend, and 6.12e7 integrated pfu observed at 18/0001UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity expected to be Low to Moderate, with a Chance of further M-Class flares, and a very Slight Chance of isolated X-Class flares.

Solar Wind / Geomagnetic Activity: Solar wind speeds should continue a declining trend to slightly elevated levels during days 1 and 2 (18-19 June), probably persisting into day 3 (20 June), before potential connection to either CH13 (in the south) or CH14 (in the north), with fast wind possibly arriving on day 4 (21 June) although this is low confidence as this feature was not evident on last rotation. Geomagnetic activity is expected to be mostly Quiet, with slight chance

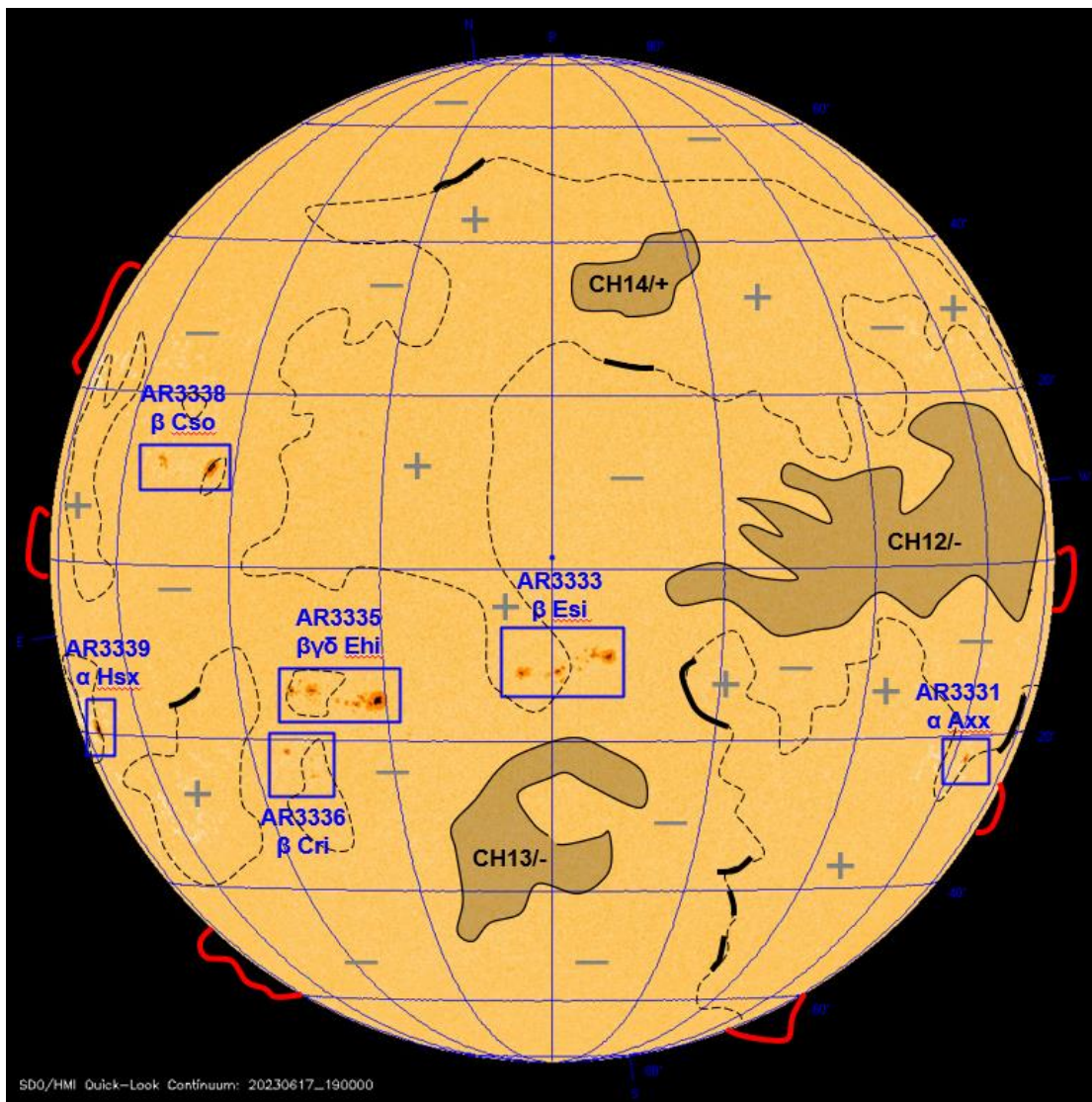
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of Unsettled intervals throughout. Slight chance of increasing to Active levels by day 4 (21 June) with a possible fast wind arriving from either CH13 (in the south) or CH14 (in the north), although this is low confidence. No CMEs currently feature in the forecast.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain at Background levels, though a very Slight Chance of enhancement throughout given the current configuration of front-sided sunspot groups.

High energy electron flux (greater than 2MeV) has been revised to show a likely sharper and greater increase in magnitude, probably odds-on for exceedance of Active 24-hour fluence from day 1 (18 June).

Figure 1. Solar Analysis Valid 17/1900 UTC.



Key: Filament ____, Prominence ____, Magnetic Field Line - - -, Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α - β - $\beta\gamma$ - $\beta\gamma\delta$ and Zurich-McIntosh Axx etc.

Geomagnetic Storms:

No Earth-directed CMEs currently feature in the forecast.

Geomagnetic activity is on a declining trend after the recent fast wind from CH12, which is expected to be mostly Quiet, with slight chance of Unsettled intervals, during the coming days. There is a slight chance of geomagnetic activity increasing to Unsettled or Active levels by day 4 (21 June) as we see a possible weak connection to either CH13 (southern hemisphere) or CH14 (northern hemisphere), although very weak signals in Enlil for these features, due to lack of evidence on previous rotation and they appear small in size. MOSWOC Enlil's handling of the current fast wind is reasonable, perhaps slightly underdone by 50km/s but improved versus recent runs, and the gradual decline from here is accepted as good guidance.

Solar wind speeds should gradually decrease to Slightly elevated levels through day 1 (18 June), probably remaining at this level throughout the period. A slight chance of solar wind increasing to Elevated levels if connection to CH13 or CH14 is achieved by the end of the period - low confidence. Geomagnetic activity is on a declining trend after recent fast wind from CH12, becoming mostly Quiet, with a slight chance of Unsettled intervals over the coming days. Slight chance of increasing geomagnetic activity by day 4 (21 June) with Unsettled or Active intervals, if connection to either CH13 or CH14 is established, although this is low confidence.

A large filament has recently lifted off the NW quadrant, although still awaiting imagery for potential CME from this event. Given its location, this could potentially have an Earth-directed component.

Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	No	5	1	1	5
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Figure 2: BGS estimated planetary K index (Kp)

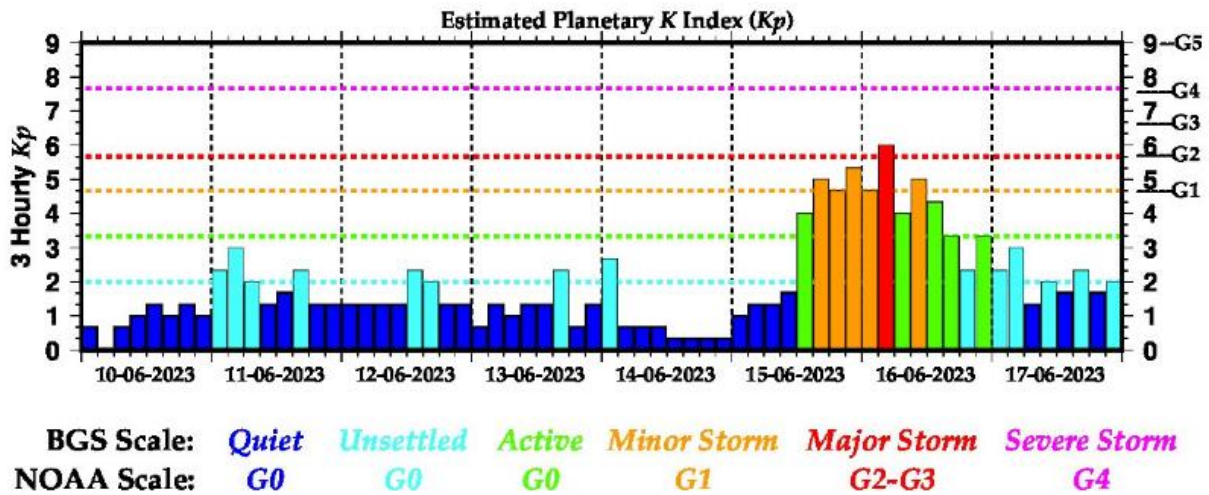
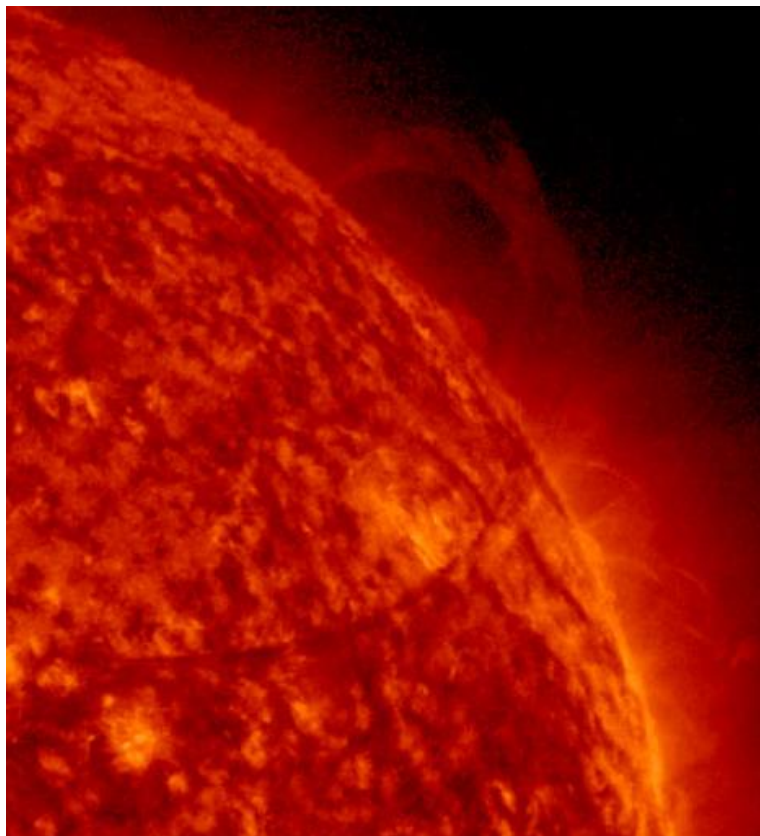


Figure 3: SDO/AIA 304 shows a large filament in the NW quadrant, which has recently lifted off – awaiting further imagery for potential Earth-directed CME.



Radio Blackouts - X-Ray Flares:

There are currently six sunspot regions on the visible disc. The largest and most magnetically complex is AR3335 (Ehi/Beta-Gamma-Delta) located in the southeast quadrant, which contains two weak delta spots in its leading portion. Despite its complexity, this region has only produced minor C-class flares in the past 24 hours. The second largest is AR3333 near centre-south of the disc, although despite its complex appearance is only an Esi/Beta configuration, with some signs of decaying within its intermediate spots. Newly numbered AR3339 in the southeast is a simple Hsx/alpha configuration, although it remains to be seen if any further development is likely to emerge from plage following on beyond the east limb.

No significant regions are due to leave the disc in the coming four days, however further regions potentially approaching the east limb as inferred by brighter flux regions in STEREO A and SDO imagery. As there is not yet significant activity from over the east limb, flare probabilities are kept flat until these regions become visible and can be analysed. All considered, solar activity carries a Chance of further M-class flares, with a very slight chance of isolated X-Class flare activity, with this risk mostly presented by AR3335.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	40	40	40	40
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 4: GOES X-Ray flares

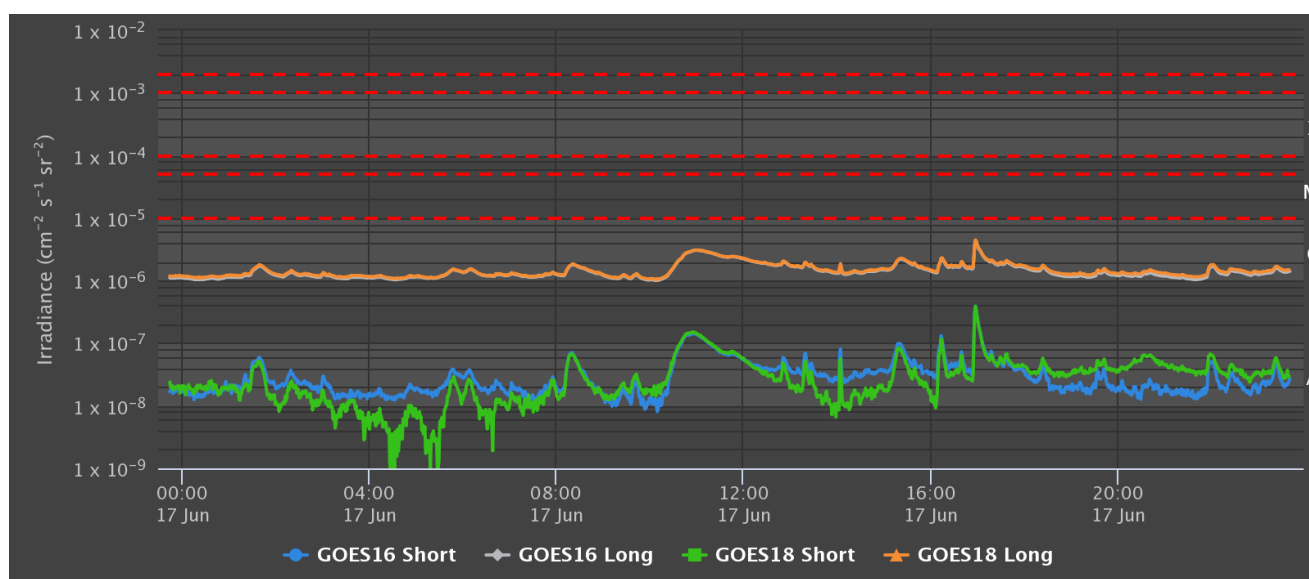


Figure 5: SDO/HMI intensitygram (left) and magnetogram (right) – shows weak delta spots in leading portion of AR3335.

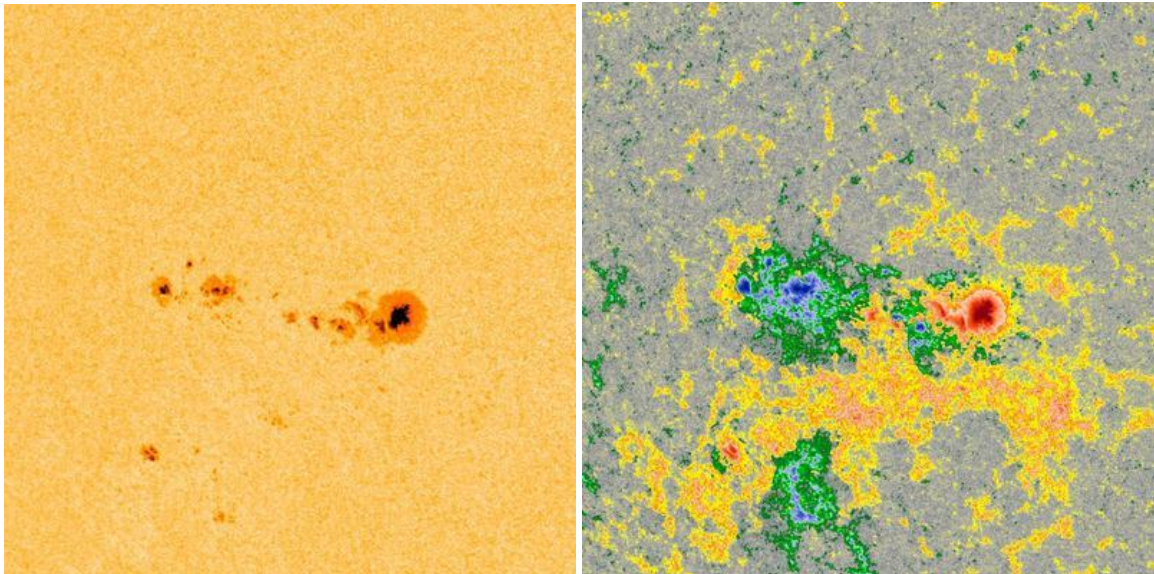
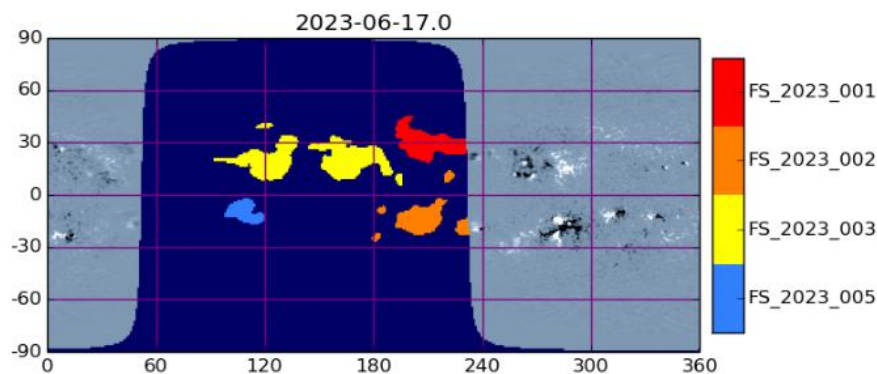
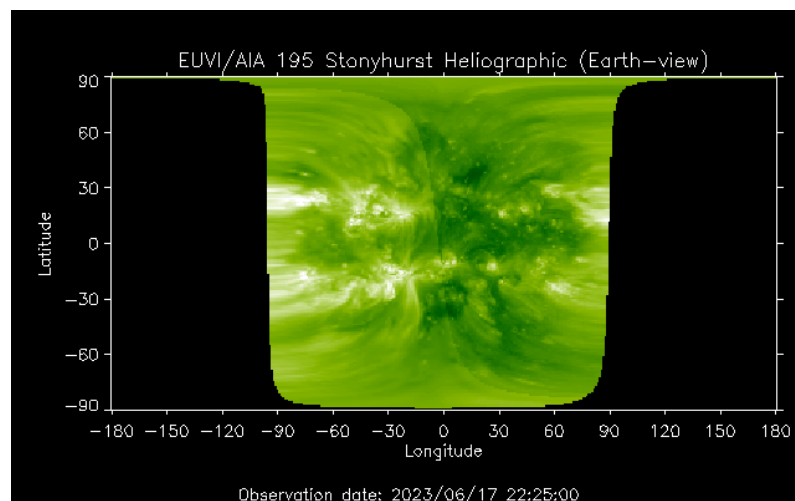


Figure 6: EUVI 195 (top) shows bright flux regions close to the east limb, due to rotate onto visible in coming days – also see the Stanford Seismic Monitor of the Sun’s far-side (bottom) which shows large regions on far-side of Sun approaching east limb.



Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux is expected to remain at background levels. Slight chance of S1 given the sunspot groups on disc, although most of these are currently located in the eastern hemisphere and not in a geo-effective location.

Radiation Storms	Level ($\text{cm}^{-2} \text{sr}^{-1} \text{s}^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	$\geq \text{S1}$	No	5	5	5	5
Very Active	$\geq \text{S3}^*$	No	1	1	1	1

* S3 $\geq 10 \text{ MeV} \geq 1000 \text{ pfu}$ and / or $\geq 50 \text{ MeV} \geq 10 \text{ pfu}$. (pfu = $\text{cm}^{-2} \text{sr}^{-1} \text{s}^{-1}$)

High Energy Electrons Event ($\geq 2\text{MeV}$):

High energy electron flux (greater than 2MeV) is expected to Moderate to High levels throughout the period. The unexpectedly potent fast wind emanating from CH12 likely to provide the impetus for at least diurnal peaks within High flux. This may mean that 24-hour integrated fluence could rise above active levels as early as day 1 (18 June), as the effects of fast wind from CH12 continues to wane, allowing the charged Van Allen belt to recover to register fully at GOES16. The forecast is now for a significant upturn in flux and fluence throughout the period, with exceedance of Active likely by day 1 (18 June).

MOSWOC REFM is showing a forecast trend in excess of that proposed by persistence, and this appears realistic, even if the exact timings are lower confidence.

GEO Electron Environment	Level ($\text{cm}^{-2} \text{sr}^{-1} \text{day}^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	$\geq 2 \text{ MeV}$ $\geq 1 \times 10^8$	No	90	90	80	70
Very Active	$\geq 2 \text{ MeV}$ $\geq 1 \times 10^9$	No	5	5	5	5

Figure 7: MOSWOC REFM electron fluence – observations and forecast.

